

REMARKS

Claims 22, 29, and 58 have been amended. Claims 22-35, 58, and 60-62 are now pending. Applicant reserves the right to pursue the original claims and other claims in this and other applications. Please reconsider the above-referenced application in light of the amendments and following remarks.

Claims 22-35, 58, and 60-62 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No.: 5,739,579 ("Chiang") in view of U.S. Patent No.: 6,016,000 ("Moslehi"). The rejection is respectfully traversed.

The cited references do not teach or suggest the subject matter of independent claims 22, 29, and 58. Specifically, the cited references do not teach or suggest "forming a top heat-radiating layer comprising aluminum nitride, wherein said heat-radiating layer is formed *completely on* an upper surface portion of [a] copper conductor," as recited in claim 22 (emphasis added), or "forming a heat-radiating layer comprising aluminum nitride, wherein said heat-radiating layer is formed *completely on* an upper surface portion of [a] first conductive plug," as recited in claim 29 (emphasis added), or "forming a heat-radiating layer, wherein said heat-radiating layer is formed *completely on* an upper surface portion of [a] second conductive plug," as recited in claim 58 (emphasis added).

For example, Chiang's FIG. 25 illustrates a conductive plug 361 surrounded by a barrier layer 360 in an insulating layer 350. A second conductive plug 394 is formed with barrier layer 393 in insulating layer 391. An etch-stop layer 392 is formed on insulating layer 391 but *not* completely on the upper surface portion of second conductive plug 394 and barrier layer 393. Consequently, Chiang does not disclose or suggest forming a heat-radiating layer *completely on* a copper conductor or conductive

plug. In fact, Chiang discloses that *barrier layer* 396 and not etch-stop layer 392 is formed completely on second conductive plug 394 (FIG. 25).

The Office Action alleges that Chiang's element 392 is analogous to Applicant's claimed heat-radiating layer. Applicant's direct the Examiner's attention to FIG. 9 of Applicant's specification. In this exemplary embodiment, heat-radiating layer 60 is formed completely on conductive plug 50. In another exemplary embodiment, heat-radiating layer 60 is formed completely on conductive plug 56 and heat-radiating layer 60a is formed completely on conductive plug 56a (FIG. 10 of Applicant's specification). This is in stark contrast to Chiang's structure illustrated in FIG. 25 which illustrates that barrier layer 390 is formed completely on conductive plug 361 and barrier layer 396 is formed completely on conductive plug 394. Since the *barrier layers* 390, 396 are formed completely on an upper surface of conductive plugs 361 and 394, per FIG. 25, the etch-stop layer 392 is *not* formed completely on the conductive plug.

Moslehi is relied upon for disclosing a method of forming an etch stop/heat-radiating passivation layer comprising aluminum nitride, and adds nothing to rectify the deficiencies of Chiang. The Office Action asserts that it would have been obvious to substitute Moslehi's aluminum nitride passivation layer for Chiang's silicon nitride etch-stop layer, since Moslehi discloses AlN is an alternative choice. It is infeasible, however, to use AlN as an etch-stop layer in Chiang since Moslehi discloses using AlN as a passivation layer and *not* as an etch-stop layer. Moreover, there is no motivation to combine the references since they teach away from the proposed combination. Accordingly, there is no suggestion in the cited references for the proposed combination.

Chiang discloses that a *single* “passivation layer may be formed over an uppermost interconnect layer . . . [and] may include . . . silicon oxynitride (SiON) or phosphosilicate glass (PSG).” (Col. 21, lines 38-42). In cases where “copper (Cu) is used for the uppermost interconnects and exposed at this interconnect layer, a silicon oxynitride passivation layer may be used.” (Col. 21, lines 45-48). Chiang does not disclose or suggest using AlN for the passivation layer, but instead uses SiON.

The Office Action alleges that Chiang discloses a heat-radiating layer 392 on conductor 394, and concludes that Moslehi’s AlN passivation layer would be substituted for heat-radiating layer 392. Layer 392, however, is an etch-stop layer and *not* a passivation layer. Moslehi discloses AlN as a substitute for a passivation layer and *not* as a substitute for an etch-stop layer. The only passivation layer Chiang discloses would be formed over the uppermost interconnect layer, *i.e.*, conductive plug 397 (FIG. 25). Chiang discloses that “[e]tch-stop layer 392 is formed over dielectric layer 391,” (Col. 21, lines 4-6) and would comprise SiON.

As a result, there is no motivation to use Moslehi’s AlN passivation layer in Chiang since Chiang discloses the use of either SiON or PSG when a copper conductor is used, as illustrated in Chiang’s FIG. 25. It is improper hindsight reconstruction to combine these two references. Chiang explicitly discloses the use of SiON as a preferred material when conductive plugs 361 or 394 comprise copper. One skilled in the art would not look to substitute Moslehi’s AlN passivation layer for an etch-stop layer comprising silicon nitride with such explicit disclosure to the contrary in Chiang.

Moreover, Chiang explicitly discloses that etch-stop layers 323, 390, and 392 *should* comprise silicon nitride. The benefit of using silicon nitride, in Chiang, is that “[s]ilicon nitride is a diffusion barrier to copper,” (Col. 2, lines 55-58). Chiang discloses that in the prior art, “interconnects should not lie on a silicon nitride layer because it

has a high dielectric constant compared to silicon dioxide.” (Col. 2, lines 58-61). Consequently, Chiang’s structure and methods *allow* a copper interconnect to be formed on a silicon nitride layer. There is no motivation to substitute silicon nitride for Moslehi’s aluminum nitride layer since Chiang is directed to solving the problem of forming copper interconnects on silicon nitride layers. As indicated above, in the prior art, it was disclosed not to form copper interconnects on silicon nitride layers. Chiang’s invention addresses this short-coming in the prior art. Consequently, the references are not properly combinable since the proposed combination would defeat the very problem that Chiang is directed to solving: forming copper interconnects on silicon nitride.

Even if the references are properly combinable, which they are not, they still do not disclose or suggest a method of forming a copper interconnect structure by “forming a first contact opening into a first insulating layer . . . forming a conductive plug in said first contact opening, wherein said conductive plug is in contact with said first insulating layer; forming a second insulating layer . . . forming a second contact opening in said second insulating layer; forming a barrier layer . . . forming a copper conductor over said barrier layer; and forming a top heat-radiating layer comprising aluminum nitride, wherein said heat-radiating layer is formed completely on an upper surface portion of said copper conductor,” as recited in claim 22. As indicated above, when a copper conductor is formed, Chiang discloses that SiON should be used. Consequently, there is no motivation to use Moslehi’s AlN passivation layer. Further, Chiang does not teach or suggest forming a heat-radiating layer *completely on* a copper conductor; but, discloses that a barrier layer 393 is formed on conductive plug 361.

The references do not disclose or suggest a method of forming an interconnect structure by “forming a contact opening in an insulating layer . . . forming a first conductive plug . . . forming a heat-radiating layer comprising aluminum nitride,

wherein said heat-radiating layer is formed completely on an upper surface portion of said first conductive plug; and depositing a second conductive plug on said heat-radiating layer in electrical contact with said first conductive plug,” as recited in claim 29. Chiang does not teach or suggest forming a heat-radiating layer completely on a first conductive plug; but, discloses that a barrier layer 393 is formed on conductive plug 361. Further, Chiang does not disclose or suggest that a second conductive plug is formed *on* a heat-radiating layer. Chiang’s second conductive plug 394 is formed on the first conductive plug 361.

The references do not disclose or suggest a method of forming a copper interconnect structure by “forming a first contact opening into a first insulating layer . . . forming a first conductive plug . . . forming a second insulating layer . . . forming a second contact opening . . . forming a barrier layer . . . forming a second conductive plug over said barrier layer; and forming a heat-radiating layer, wherein said heat-radiating layer is formed completely on an upper surface portion of said second conductive plug,” as recited in claim 58. Chiang does not teach or suggest forming a heat-radiating layer *completely on* a second conductive plug; but, discloses that a barrier layer 393 is formed on conductive plug 361.

Claim 23-28 depend from claim 22 and should be similarly allowable along with claim 22 for at least the reasons provide above, and on their own merits. Claim 30-35 depend from claim 29 and should be similarly allowable along with claim 29 for at least the reasons provided above, and on their own merits. Claims 60-62 depend from claim 58 and should be similarly allowable along with claim 58 for at least the reasons provide above, and on their own merits.

In view of the above, each of the presently pending claims in this application is believed to be in immediate condition for allowance. Accordingly, the Examiner is respectfully requested to review and pass this application to issue.

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Respectfully submitted,

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